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DEMONSTRATION OF THE PORE SYSTEM OF SOME MEMBRANE FILTERS[1]

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In medicine membrane filters were used for the detection of bacteria and for sterile filtration. For these studies the most exact knowledge possible on the width and arrangement of the pores inside the filter of importance.

Until now, indirect methods were employed for the determination of pore width (bubble pressure processes, method of measuring the passage velocity). All these processes indeed yield exact values of the differential filtration performance of the membrane types, however they give no adequate picture of the reliability of the individual filters; because the requisite of identical width of all pores is an essential condition for the value of any filter. Moreover the homogeneity of the pore arrangement on a unit of surface is also of importance. These properties however can not be evaluated adequately by indirect methods. Here only optical demonstration will help.

Since the pore width of the membrane filter lies far under the resolving capacity of the light microscope, such studies could be carried out only with an electron microscope (Hansmann and Pietsch, 1949; Holmcke, 1952). The technique of preparation which are here considered (carbon "wrapping" process, metal evaporating) must first spread out as a very thin, radiatable section over the surface and pore walls. This section after chemical dissolution of the membrane substance (nitrocellulose) becomes a suitable object for study with the electron microscope.

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1. Membrane filter corporation - Sartorius-Werke) Gottingen.

Thanks to the high depth of focus of the electron microscope, stereoscopic pairs of photographs can be made from such preparations without difficulty. These photos can be evaluated with suitable inspection and measuring apparatuses.

With both methods of preparation, one can obtain equal pictures from a given filter in spite of the differential methods. (Figs 1a and 1b). Since the hollow spaces were filled with carbon or metal sections, they appear after dissolution of the nitrocellulose as empty covers of bubbles and bubble like structures.

The individual bubbles (vesicles) are depressed into the substance of the filter away from the surface and appear to have approximately equal diameters for a given filter. In the depth of the filter adjacent bubbles fuse together lightly so that not only longitudinal tubes are formed by the chain-like string but also crypt-like pore space systems, which stretch inall dimensions far beyond the average cross section of the individual bubbles.

Stereoscopic measurements yield average values which do not justify a generalization however. Especially the research material of each type of membrane material was much too small to be able to make binding statements on the possible (feasible) width of the pores. Nevertheless the five types of membrane filters which were studied are so different that without much training each type is easily recognized in the electron microscope pictures.

Both the fine pore filters ("finest" and "fine") may be grouped together as can also both the wide pored("coarse" and "coarsest") filters, whereas the "medium" filter is distinct from both other groups.

In order to clarify the question which appears important to medicine, of whether the bacteria are kept back completely by the filtration, we studied several membrane filters with an electron microscope after the bacteria-containing fluids were run through them. In so doing bacteria which were held back could repeatedly be observed on the surface of the filter (Bact. coli, Bact. subtilis); moreover no bacteria have been fastened on the inside of the pores up til now. To be sure it is still not certain from this whether all bacteria were held back by the filter.

These studies have indeed shown (1) that the makeup and the structure of the membrane filter can be demonstrated with the electron microscope, (2) that stereoscopic measurements are also obtainable. However, no binding statements on an average pore width can be deduced as long as there are not studies of series of many filters of the same type.

LITERATURE

Hannmann, G. and H. Pietsch: Electron microscope illustration of surfaces of membrane filters. Naturwiss 36: 250 1949.

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Figures

Fig. 1. Average membrane filter, carbon replica, 4000:1.

Fig. 2. Average membrane filter, metal evaporation, 4000:1.

Fig. 3. Coarse membrane filter, metal evaporation, 4000:1. (stereoscopic pictures).

Fig. 4. Average membrane filter, with *E. coli*, fixed with $Os0_4$, metal resistance, 4000:1 (stereoscopic pictures).